ORFI Systems, Inc.

Report No. OSI-9204-67

CHARACTERISTICS OF COMMON LANDSCAPE FEATURES

Rocks and Trees

Prepared By
Harold L. Heller

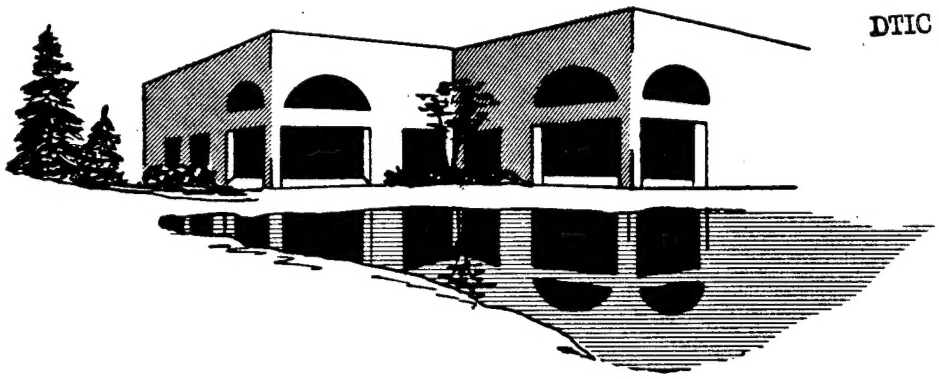
For
ORFI Systems, Inc.
41 Great Valley Parkway
Malvern, PA 19355

U.S. Naval Warfare Center - Aircraft Division
Contract No. N62269-91-C-0022

CDRL A001 - Task Report

FRC Project P2790001

Franklin Research Center
2600 Monroe Boulevard
Norristown, PA 19403



1.0 INTRODUCTION

This study was undertaken to determine the most common types of vegetation and rocks found on a world-wide scale. The desired results of this study were to find the minimum number of vegetation and rock types that would fit in anywhere on a world wide scale where natural vegetation and rocks are found so that only a small number of stock camouflage types of each need be made.

2.0 VEGETATION

Library searches revealed a wealth of literature, most of which is not organized in any precise systematic or area-specific distribution. Much of the information is contained in library reference volumes. A bibliography of the most useful references is included in the appendix.

From an overview of the available data, two approaches to the study of vegetation distribution were found. One approach was to look at vegetation communities based on environmental conditions (zoning) such as rain forests and prairies and choose plants from each, and the other was to choose specific types of vegetation and see where they exist. Both approaches were pursued to fully understand the scope of the model types needed.

2.1 VEGETATION ZONING

Vegetation on a world-wide basis is divided into eight or more categories, each containing a variety of plants that grow under specific climatic conditions. These conditions or controls of the plant communities are: 1) temperature, 2) solar radiation, and 3) precipitation. Temperature and radiation are latitudinal controls, whereas, precipitation is dependent upon available moisture and air movement, resulting in erratic patterns over the earth. Thus, it is possible for a desert to exist next to a rain forest.

Besides the north-south temperature gradient, there is also an altitude-temperature gradient. The biota zoning on the altitude (vertical) gradient are similar to those on the latitudinal (horizontal) gradient.

For this study an eight category system was chosen. These categories are : 1) tundra and ice, 2) taiga, 3) temperate deciduous forest, 4) Mediterranean scrub forest, 5) grassland, 6) desert, 7) tropical rain forest, and 8) temperate rain forest. A world map of these categories is shown in Figure 1. A brief description of each of these categories is presented below:

1. Tundra

This is the most northern zone, extending around the Arctic Ocean. (There is no similar vegetated region in the Southern Hemisphere, due to the lack of land masses in the plant producing latitudes.) Frost can occur year-round, and there are no upstanding trees. The vegetation of interest here is bushes of birch, willow, alders and conifers, dwarfed by the severe weather conditions.

2. Taiga

The taiga is a broad zone below the tundra in which there is a summer growing season. Only a very small taiga zone exists in the Southern Hemisphere, along the western side of South America. In this zone hardy coniferous forest grow, along with thickets of alder, birch and juniper.

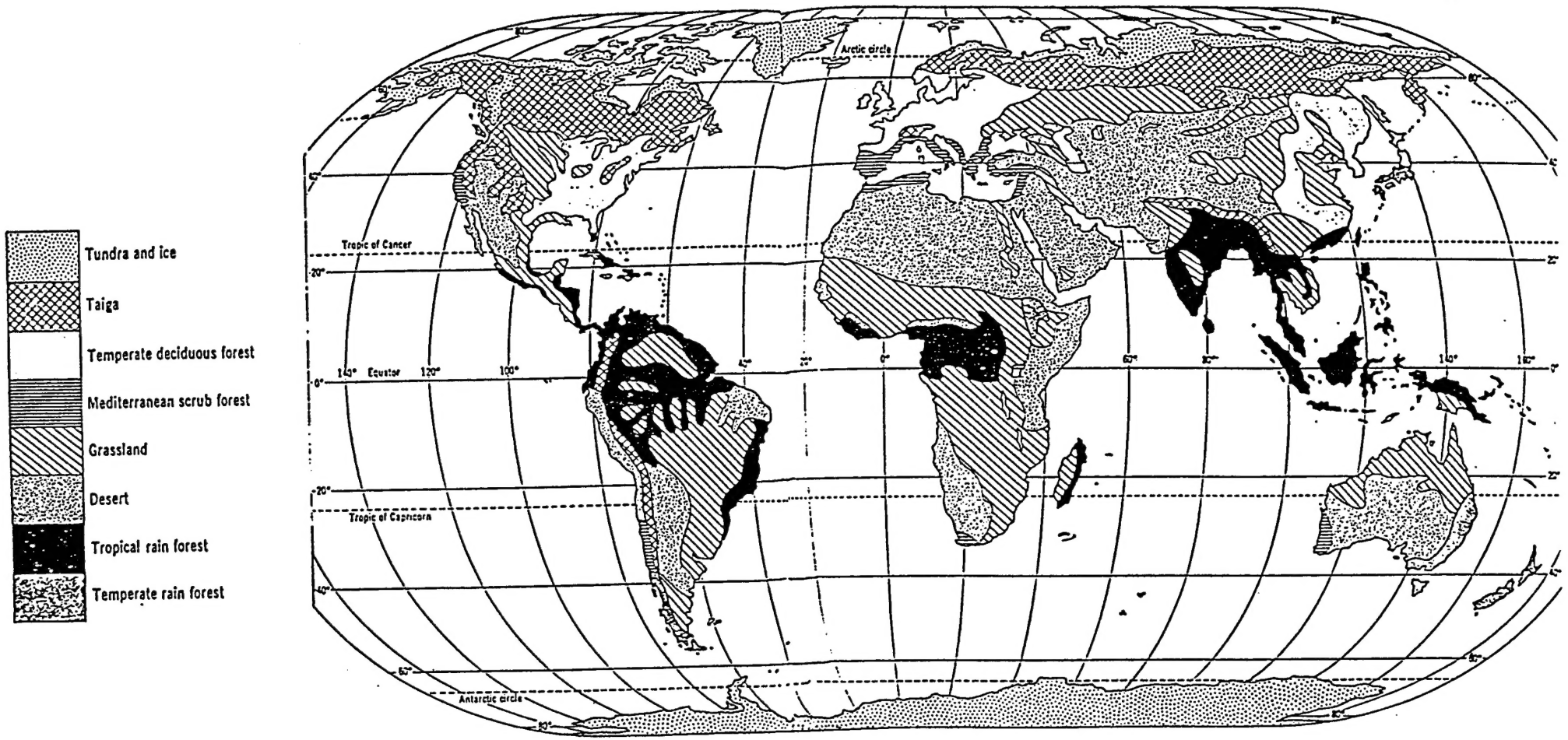


FIGURE 1: VEGETATION CATEGORIES AND THEIR WORLDWIDE DISTRIBUTION.

(from: Simson, G. and Beck, W.; *Life*, ed.2, p708; Harcourt, Brace & World.)

(2-1/2-2 blank)

3. Temperate Deciduous Forests

This is a temperate zone with about 40 inches of rainfall annually. Deciduous trees are those that lose their leaves in the fall and grow new ones in the spring. Much of the deciduous forests consist of varied, local groupings of three types, resulting from the soil type and drainage for any given area. Typical trees of this zone are beech, tulip, sycamore, oak, maple, elm, poplar, birch and hickory.

4. Mediterranean Scrub Forest

This zone is a small one, chiefly located around the Mediterranean Sea, with other small areas in California, western Australia, the tip of Africa, and Chile. Small evergreens and thorny shrubs are typical in these woodlands.

5. Grassland

These areas are often called prairies, steppes, savannahs, pampas and velds. The water supply in this region is not enough to support trees; so the dominant vegetation is grass and shrubs. Rainfall in these regions is low and erratic.

6. Deserts

Deserts have low rainfall, generally under 10 inches per year, have very hot days and cold nights. The land can be completely lacking in vegetation, or have an abundance of plants and bushes. Typical plants in this zone are cactus and Joshua trees. Annual plants in the desert have small leaves or none at all.

7. Tropical Rain Forests

Rain forests are a complex grouping of plants, requiring high moisture levels. They usually consist of over a hundred species of trees, providing a unique system of stratification. Vines that climb from the ground to the top of the canopy of trees are common. As denoted by the name, these forests exist in the hot tropical regions of the world.

8. Temperate Rain Forests

This is a rather small category with forests existing at the southeastern end of South America, western Australia, New Zealand, Japan and Ethiopia. Ferns and mosses thrive in these forests.

2.2 TREE TYPES AND THEIR DISTRIBUTION

The best source of information was found in the Oxford Encyclopedia of Trees of the World; Bayard Hara; Oxford University Press, 1981. This book showed areas of the world covered by many species. Due to the small sizes of the maps, it did not show local variations such as higher or lower elevation, and wet or dry lands. A set of world maps were made and taken to the library to use for outlining the 14 most widespread tree types. These maps are included as an appendix to this report and are presented in order of largest area coverage for a given genis to the least.

Most of the tree/bush types from this set show distinct bands around the world in which they grow (latitudinal zoning). Examples of this are maple, oak and birch, which occur above the Tropic of

Cancer, and acacias and figs which grow within the 40th parallels. There is one type, however, that is world-wide. This is the genis salix which includes the willows, sallows, and osiers. Its broad range indicates that it is temperature insensitive and therefore would grow at all altitudes where shrubbery is found.

Figs and hackberries are the next most widespread tree types in the world, and are more restricted to the temperate and tropical zones.

Continuing on down the list in decreasing world coverage are: juniper, viburnums, acacias, oak, ash, (poplar, aspen, cottonwood), birch, rhododendron, the prune family, maple and spruce. All of the remaining types cover even smaller areas.

2.3 SELECTION OF VEGETATION TO DEVELOP

Identifying two to four specific types of vegetation to cover every location is not possible. The genis oak, for example, has enough distinct varieties that if one of the most common were chosen, there would be areas within the oak zone in which this type would not be found.

To overcome the problem of specific zoning (latitude, altitude and moisture content) for the different vegetation types, general leaf types/shapes were examined to identify a common world-wide form that would pass as a typical leaf form common to any part of the world where leaves are found. The selected leaf pattern should not be highly specific or showy, or difficult to replicate.

Figure 2 shows various leaf shapes, and the terms relating to them. From the chart, leaf shapes that would be difficult (but not impossible) to mold are the pectinate, pinnate and hipinnate forms. Acacia and hemlock are examples of these types. Leaf types that would stand out when in a different setting would be the palmate, sinuate and truncate patterns, examples being maple oak and fig. The ideal leaf shapes for this project use are the elliptic and ovate styles, and to a lesser degree, the lanceolate, entire, oblong-ovate and orbicular shapes.

In locations where leafy vegetation consisting of bushes and trees are abundant, a nondescript simple leaf form would work well. From the maps mentioned above, the trees genis Salix covers most of the earth, and its leaf shapes are of the simpler forms. Hackberries also have a simple leaf form and are quite widespread. The birch tree family covers most of the temperate region of the world, and has leaves that are elliptic and dentate. All of the above types might pass as a simple elliptical leaf about 2.0 inches long and 0.75 inches wide. This leaf type is shown in Figure 3.

The southwestern United States might be an area where several specific types of vegetation might be needed on a regular basis. A common tree of this area is the Joshua tree, a tall branched arborescent yucca that has short leaf clusters at the ends of the branches. Also in this region are found juniper trees in various states of decay and weathering. Models of these two plants would work well for this region, and the deadwood juniper would also work well in many other arid locations.

For the choosing of vegetation types to produce, it is recommended that first the simple leaf type plant be made, and with inputs from the area of most frequent use several more specific types could be chosen.

One problem with using leaves is that their color often changes with the seasons. Except for early development, leaf shapes are fairly consistent throughout the life of the leaf, but several color

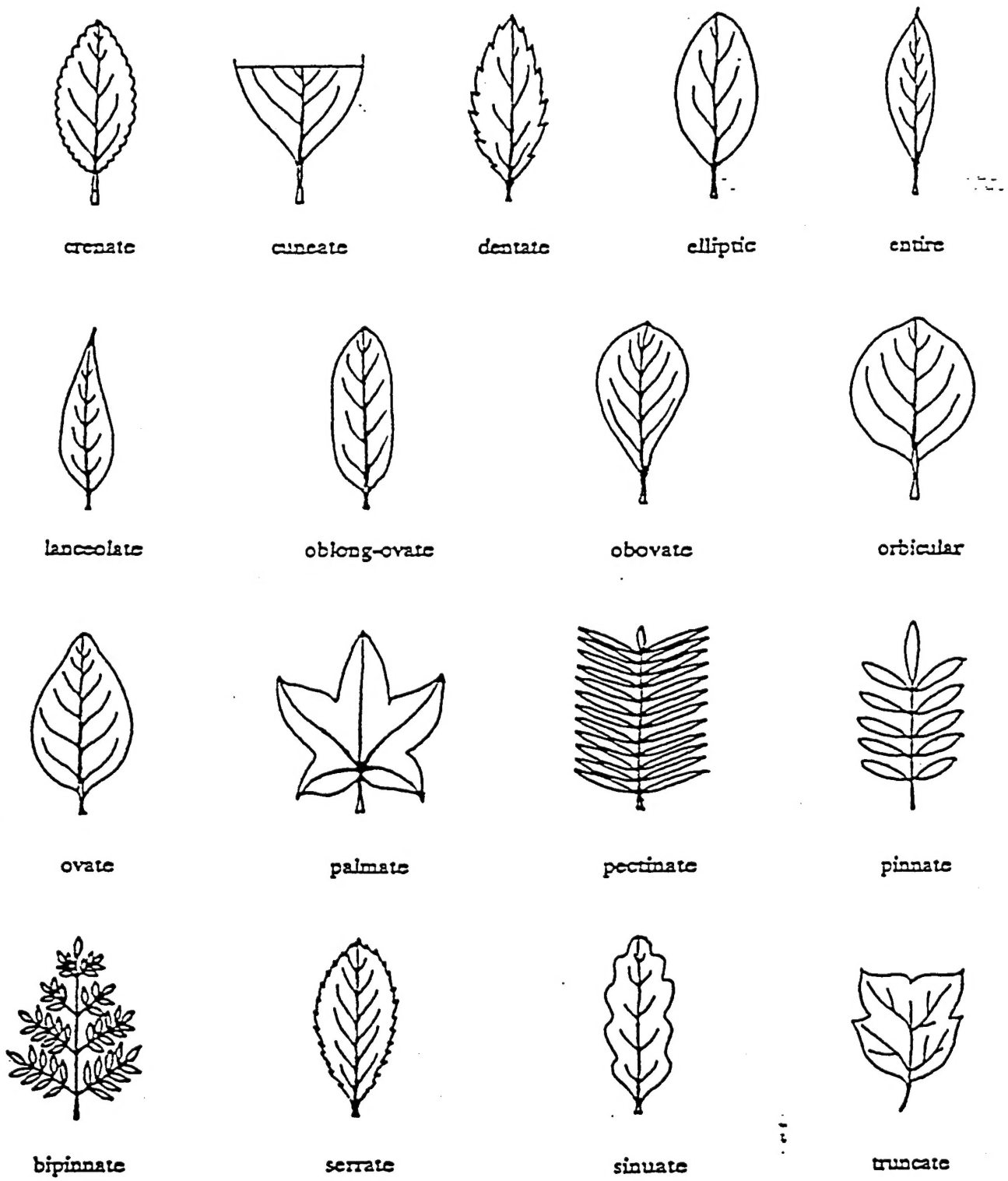
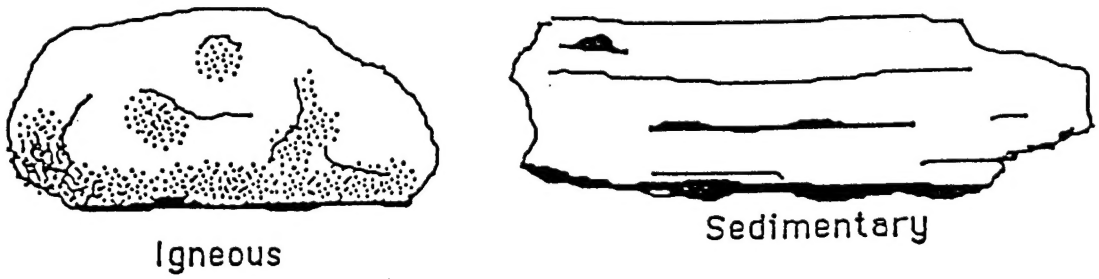


Figure 2. Terms Relating to Leaf Shape and Arrangement.

Typical Leaf Forms



Typical Rock Forms

Figure 3. Most Common Form of Leaves and Rocks.

changes can take place, or even shedding of the leaves can occur. Young leaves are lighter in color and more transparent than mature leaves, and may change color in the fall. In the temperate and northern regions there is at least a five-month period when the leaves are missing. This would make it necessary to also have in stock leafless bushes which could be used all year in almost any area of the world where bushes grow.

The size of the bush considered for use with leaves would be small, therefore avoiding the distinct characteristics of mature tree bark. Smooth grey/brown stems would be sufficient for this.

Dead or winter wood would have to be larger in diameter to cover the device. For arid regions, dead and well weathered juniper is recommended. For non-arid regions, a well decayed non-specific form could be used.

The preferred types to produce are the two dead-wood types mentioned above and the bush containing the common leaf form.

The Joshua tree (possibly difficult to mold) and a fan cactus should also be considered for use in the southwest United States.

3.0 ROCKS

Rocks are classified into three major groups. These are igneous, sedimentary and metamorphic. Igneous rocks are formed from cooled and crystalized melted silica. The most familiar igneous rock type is granite. Sedimentary rocks are formed by the deposition and compression of debris from weathered rock, and are generally recognized by their bedding planes. A very common sedimentary rock type is sandstone. Metamorphic rocks are the product of recrystallized igneous or sedimentary rock subjected to high pressure and temperature. Two very familiar types of metamorphic rocks are slate and marble.

For our purpose, color, shape and texture are the three features to consider. Color is the most important feature. It is possible that some touch-up adjustments may have to be made in the field to exactly fit a given situation. Shape is of less importance, but it has to fall within two to three types 1) rounded, 2) angular, and 3) rough or weather worn. Texture depends on grain size, which requires close observation, so it may be possible to work with one medium-sized texture.

3.1 IDENTIFICATION OF SHAPE/COLOR

An extensive literature search was carried out to determine the distribution of rock types and colors in a worldwide basis. It was quickly found that rock color is not an important issue in describing regional rock types, unless the end-use is for architectural applications.

Lacking the availability of this type of information, color on the basis of elemental content was reviewed to determine overall prevalence in the earth's crust, hopefully to find a breakdown by continent, but this information is not available. The elemental content of the entire earth's crust is interesting in that it shows iron to be quite prevalent. The table below lists the eight abundant elements.

Abundance of the Chemical Elements in the Earth's Crust	
Oxygen	46.6
Silicon	27.7
Aluminum	8.1
Iron	5.0
Calcium	3.6
Sodium	2.8
Potassium	2.6
Magnesium	2.1
All Others	1.5

The high content of iron indicates that a large portion of the earth's crust would contain the reddish-brown iron oxides.

Soil types have been studied on a world-wide basis, and are presented in map form. Some soil types are described by color and indicate the color of the rocks from which they come. This holds true for the less-vegetated, dryer regions of the world, where organic matter does not influence the color.

Large areas of the world are covered by two colors of desert sand, described as gray desert and red desert. The red desert areas include a large portion of northern Africa, the Arabian peninsula, and the southern parts of Iran and Pakistan. Other area having red desert include the south western United States and Mexico, and at least half of Australia. The gray desert sands are found chiefly in the Middle East, from central Iran north to the Ural Mountains, and eastward into Mongolia. This same color is found in the western United States.

Another classification, reddish prairie, is found in Brazil, eastern and southern Africa, northern India, Thailand, and south central United States. There is also a band of reddish prairie around the Australian desert.

Lacking visual color information, which is needed to select rock colors, 22 years of National Geographic magazines were obtained (at no cost) and were reviewed for photographs showing rocky terrain. Over one hundred good photos were found, removed from the magazines, and sorted by continent into fourteen stacks. These groupings are listed below:

Location	Rock Color
Africa	mostly buff to dark tan, some cream
Asia	from cream to tan
Australia	tan to brick-red
Russia	white to tan
China	much gray/white to tan
Arabia	gray, buff, yellow/tan, tan
India	gray/white to tan
Europe	much gray/white to tan
Israel	white to tan
North America	cream/white to tan
Central America	white to buff with much surface darkening
South America	cream/white to tan
Islands	mostly gray to tan
Arctic	gray to dark brown

The above list gives an excellent indication of the rock colors for the land masses of the world. The tan colors are attributed to the iron oxide and are found more in the sedimentary formation rather than in

the high mountains usually consisting of igneous type rocks. This information provided enough information to make selections for the stock models.

3.2 ROCK SHAPE AND COLOR SELECTION

The above list gives a good indication that four colors might satisfy any location. These would be:
1) light gray, 2) buff, 3) tan, and 4) yellow-tan.

Two major rock shapes are: 1) angular (flat edged), and 2) rounded. The angular rocks would be predominately sedimentary, and the rounded ones igneous and metamorphic. These two types are shown in Figure 3. This would mean that at least eight types would need to be stocked; however, it is somewhat unlikely that either flat-edged igneous (generally lighter colored) rocks would be needed or rounded-edge sedimentary (usually colored buff to tan) rocks.

The four basic rocks in stock models could be 1) light gray with rounded edges, 2) buff angular, 3) tan angular, and 4) yellow-tan angular. The texture of the gray rock should be rough and slightly weather worn, and the rest having fine grain with slightly rounded edges.

A problem arises with the presence of dirt and biological growth on the rocks. A clean rock will stand out from all others around it, so the stock covers should have some darker colored area, especially on the less weather exposed sides. It may be possible to add the final incrustation at the time of shipment for a particular location since a wet area incrustation will be different from that of an arid location. It may also be possible to have a can of spray adhesive in the kit, and when the cover is put in place, adhesive may be applied and the surrounding natural dirt thrown on it.

4.0 APPENDIX A

FIGURES A-1 THROUGH A-14:
MAPS OF SPECIFIC TREE-TYPE LOCATIONS

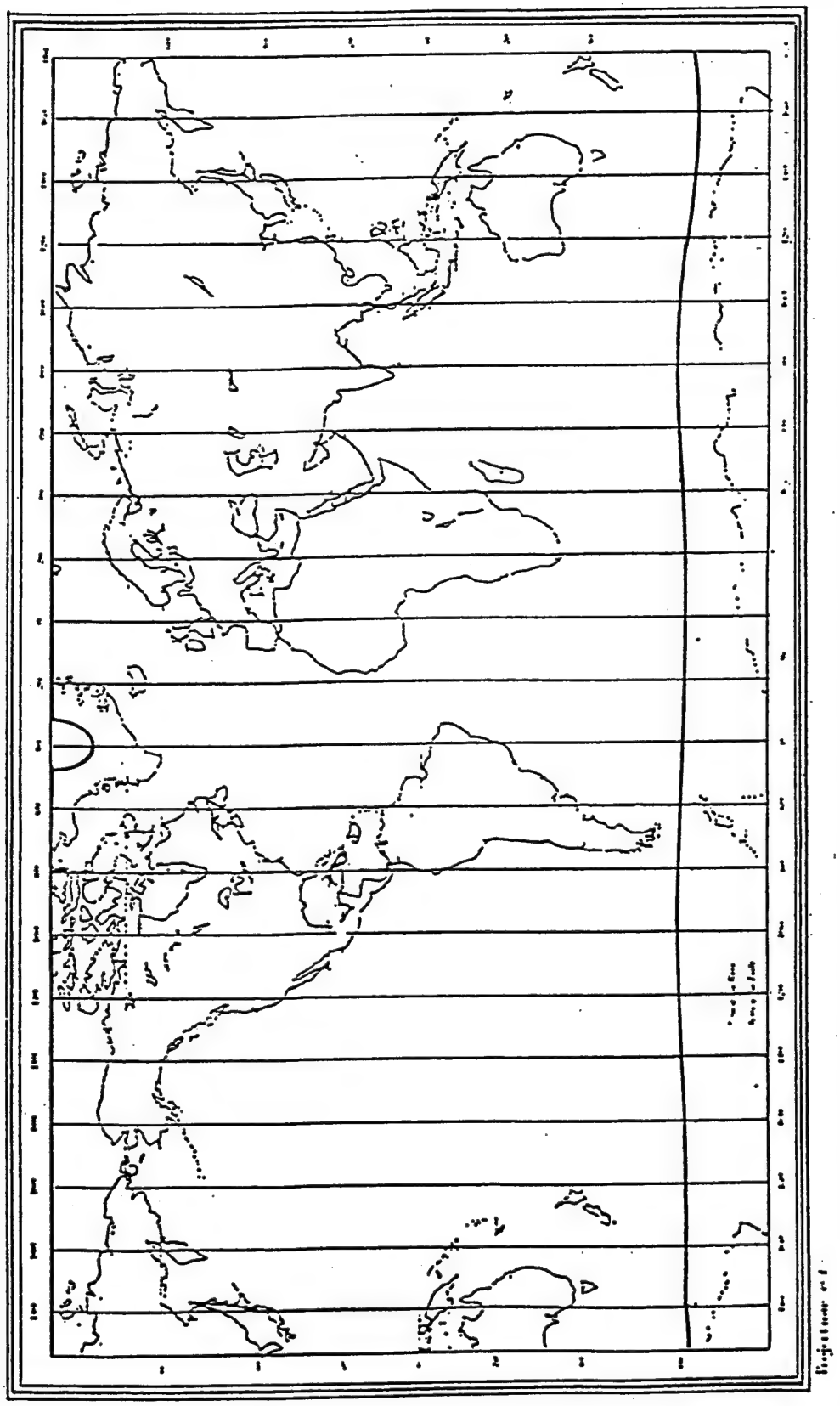


FIGURE A-1. WILLOWS, SALLOWS, OSIERS (Salix)

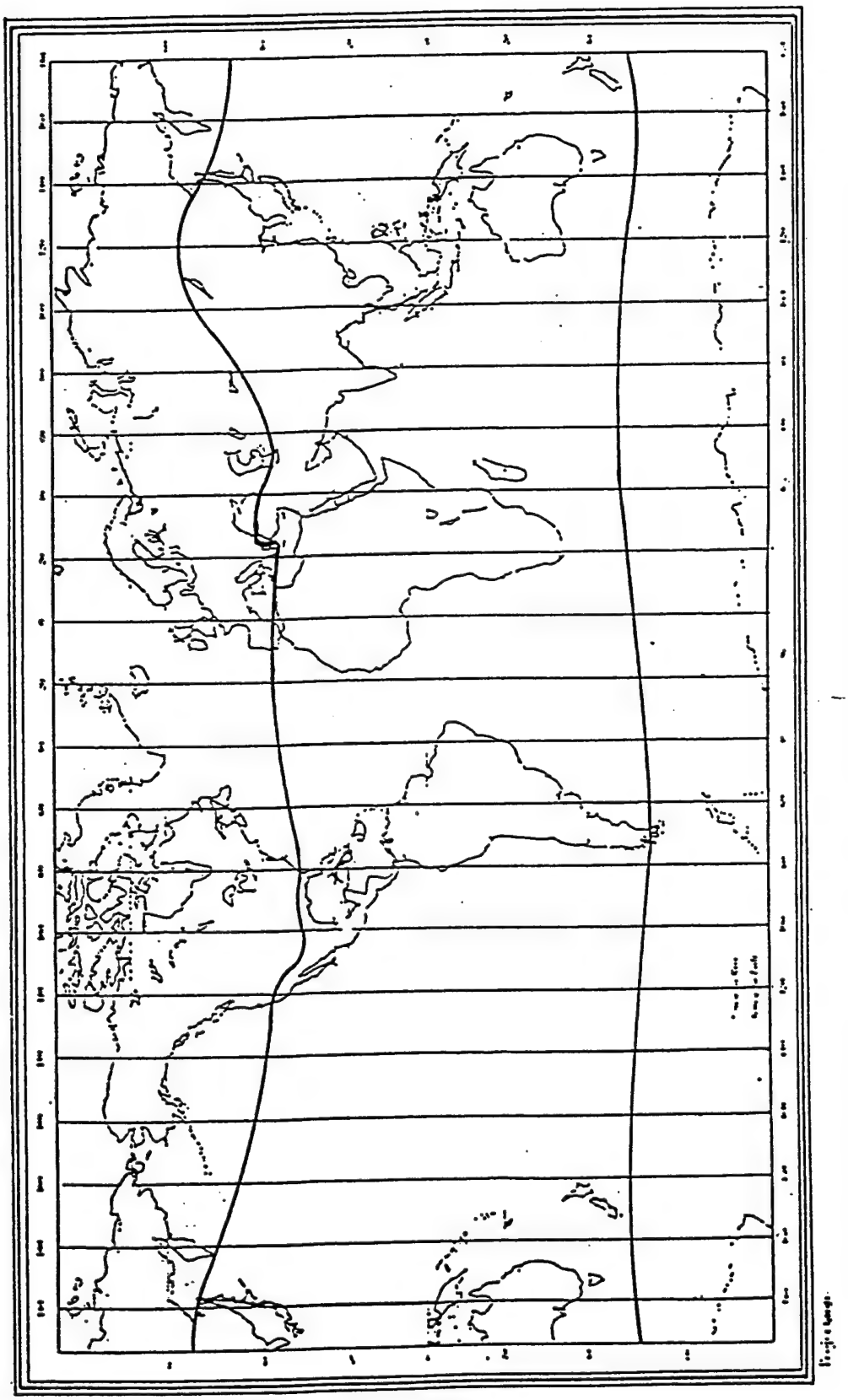


FIGURE A-2. FIGS (Ficus)

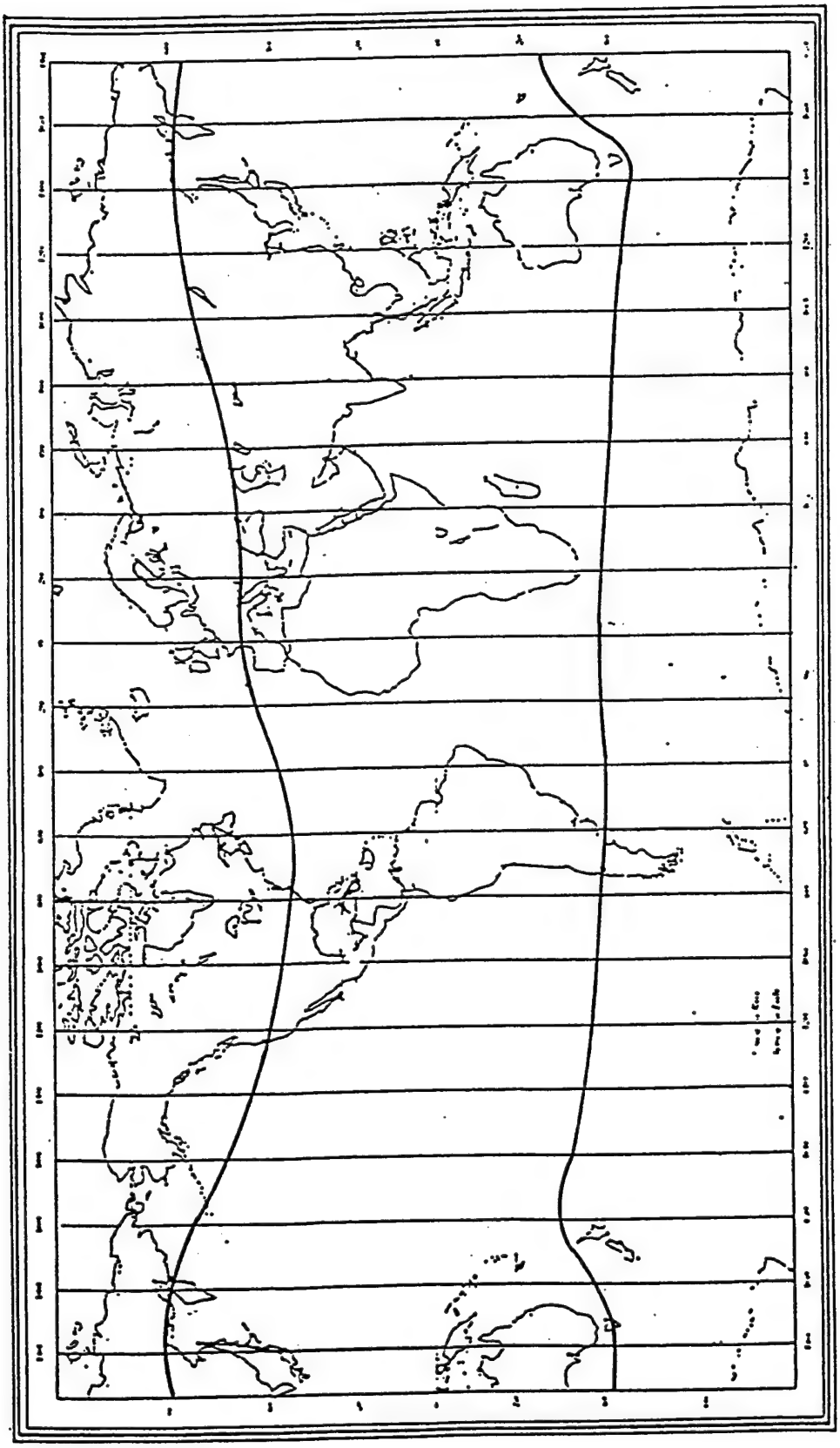


FIGURE A-3. HACKBERRIES (Celtis)

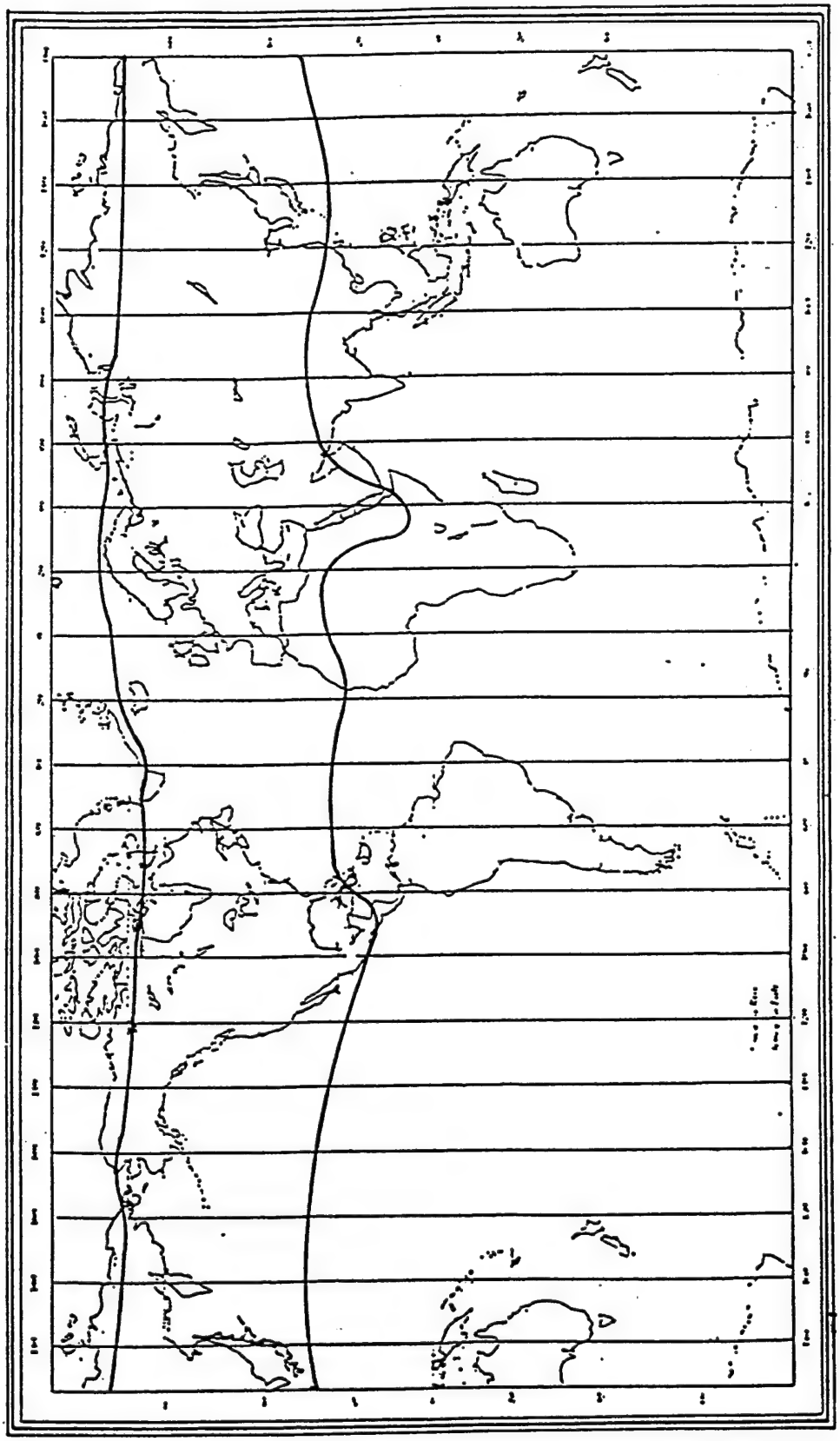


FIGURE A-4. JUNIPER (Juniperus)

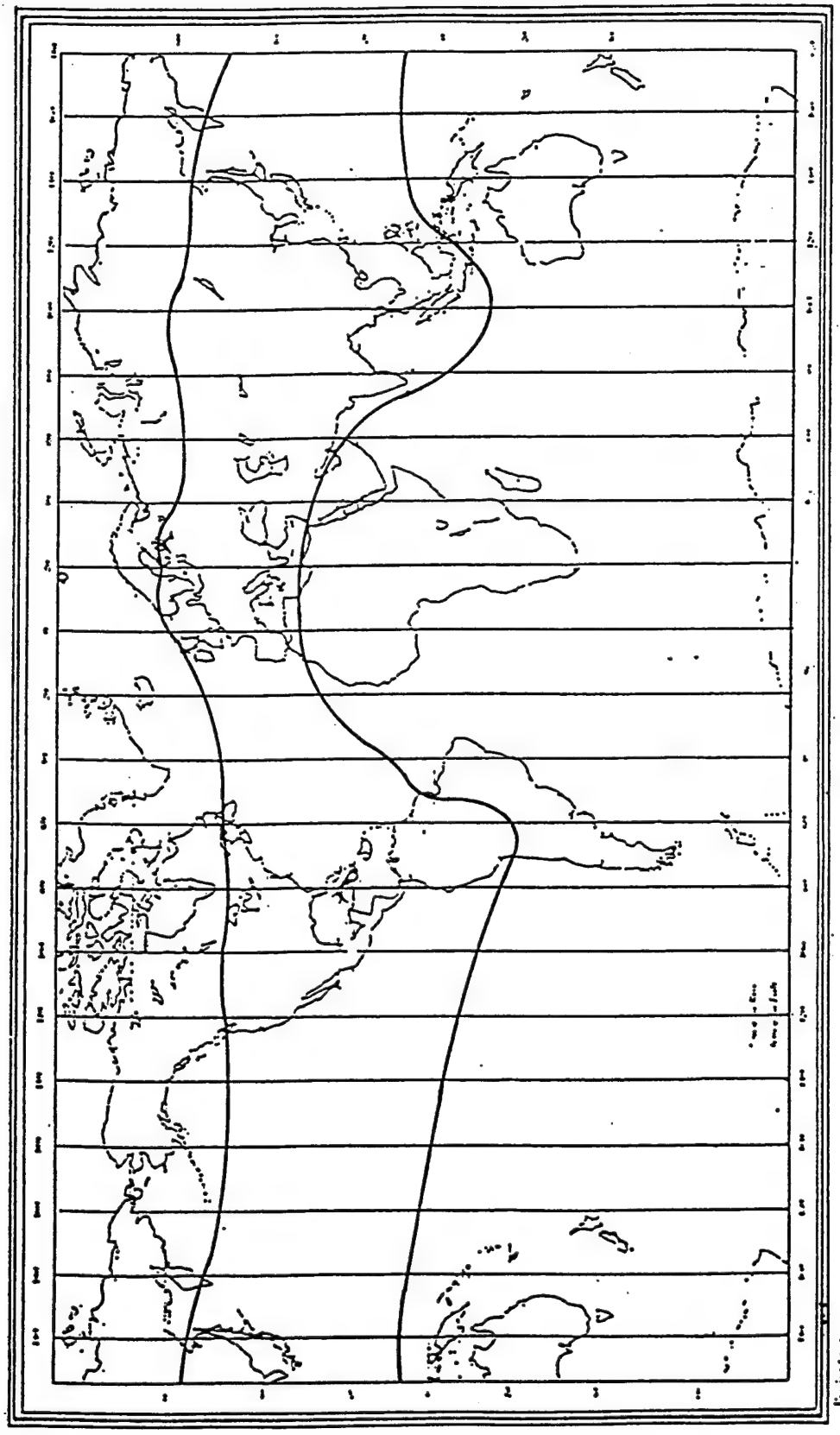


FIGURE A-5. VIBURNUMS (Viburnum)

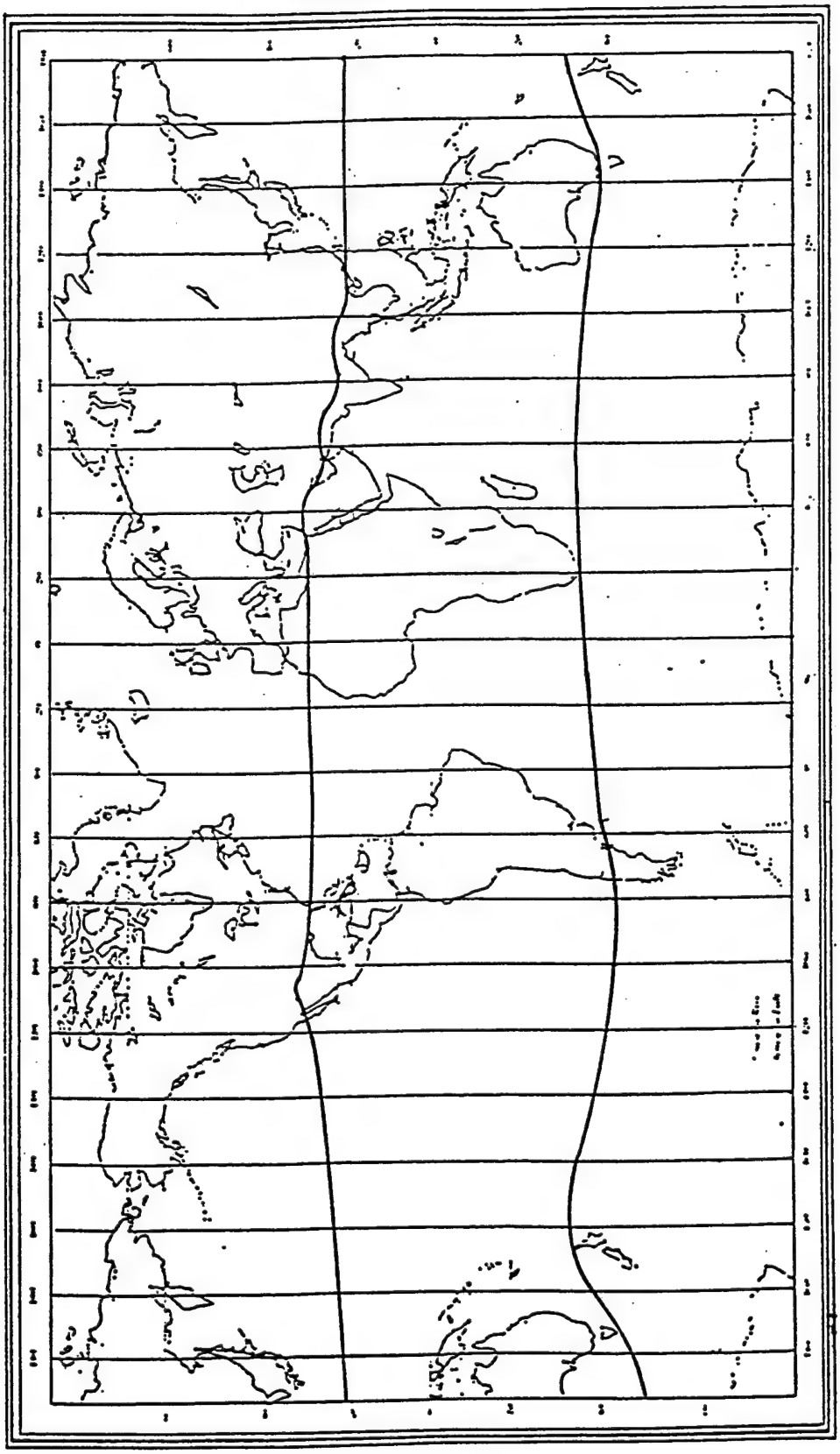


FIGURE A-6. ACACIAS (Acacia)

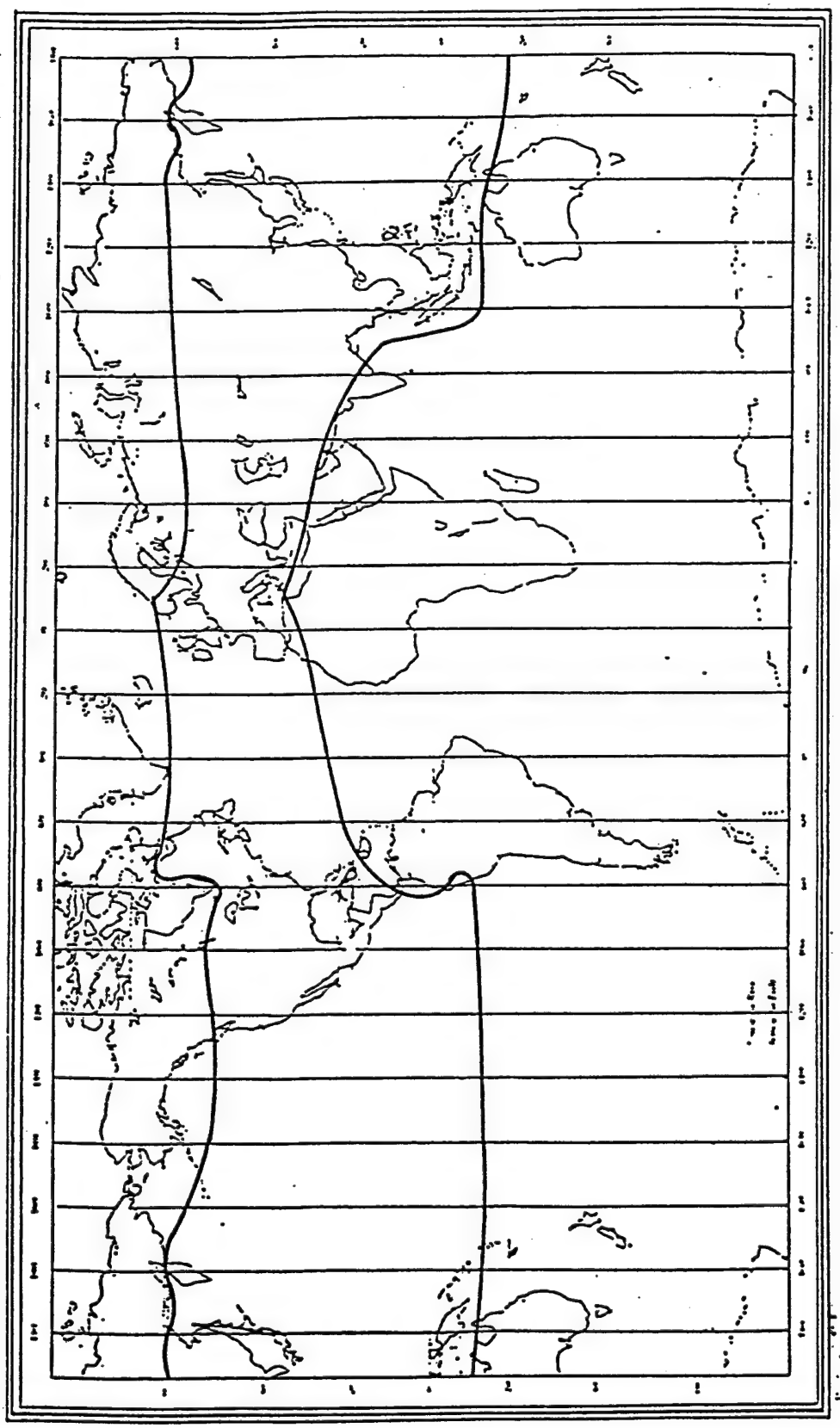


FIGURE A-7. OAK (Quercus)

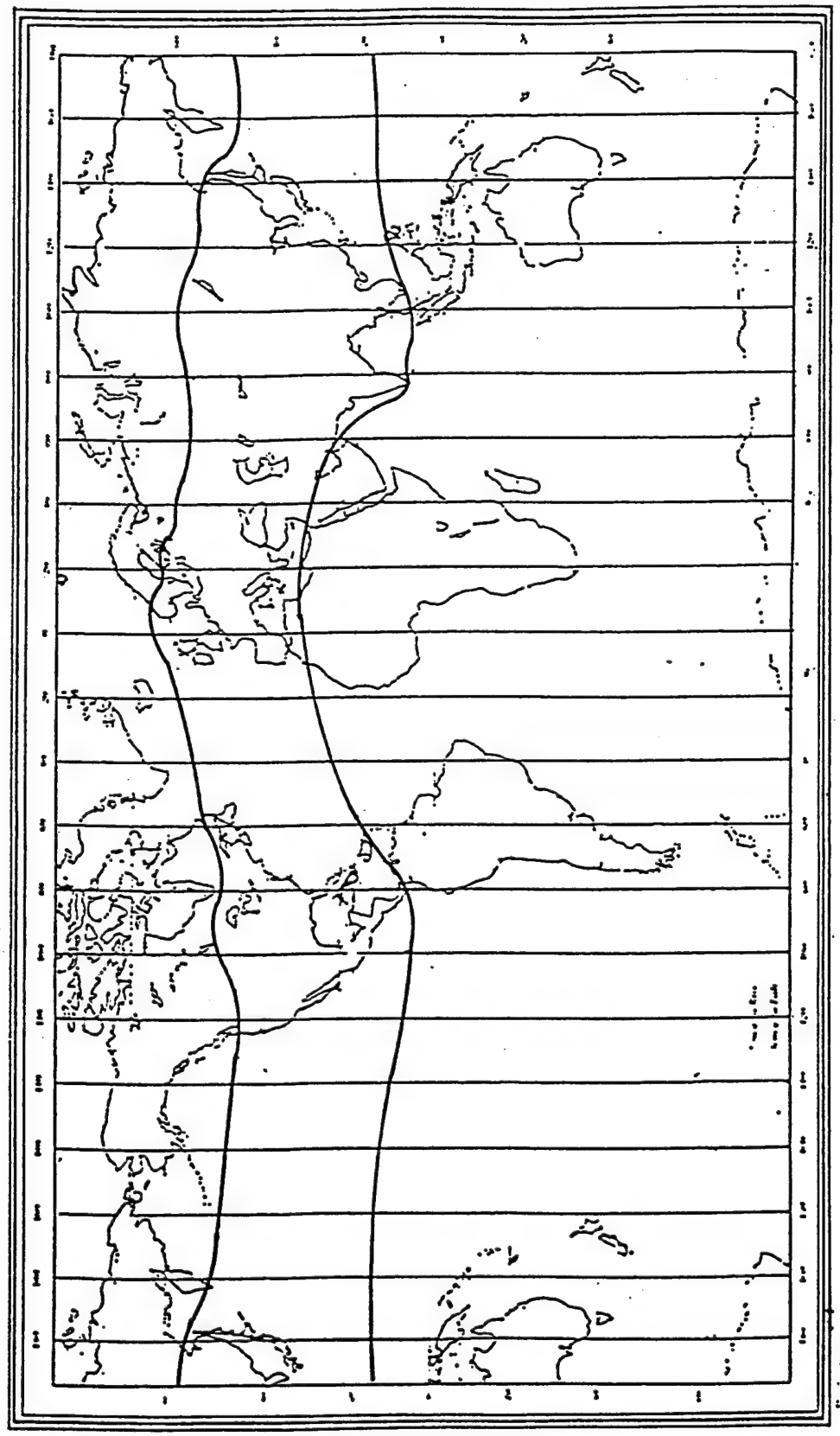


FIGURE A-8. ASH (Fraxinus)

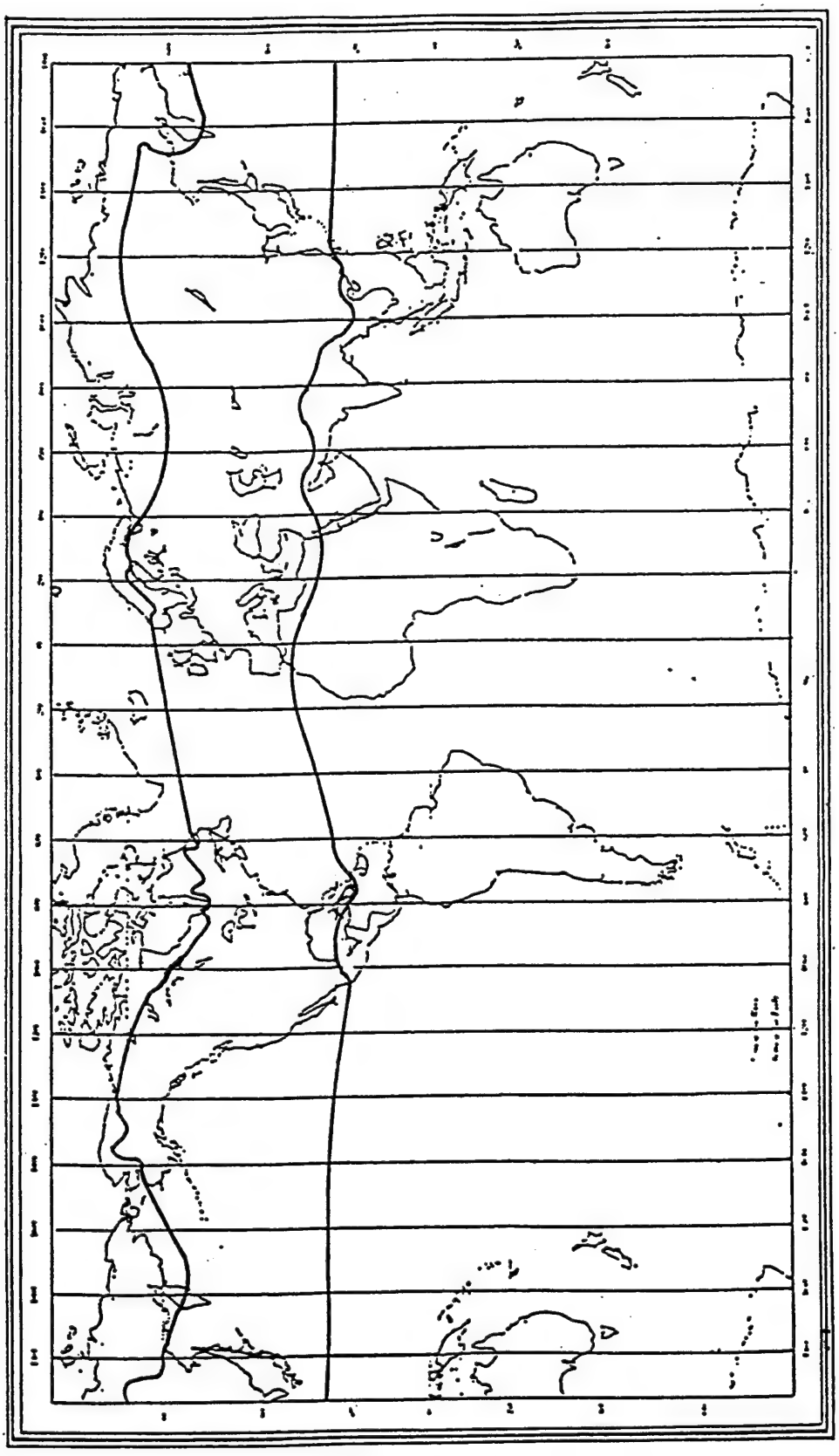


FIGURE A-9. POPLAR, ASPEN COTTONWOODS (Populus)

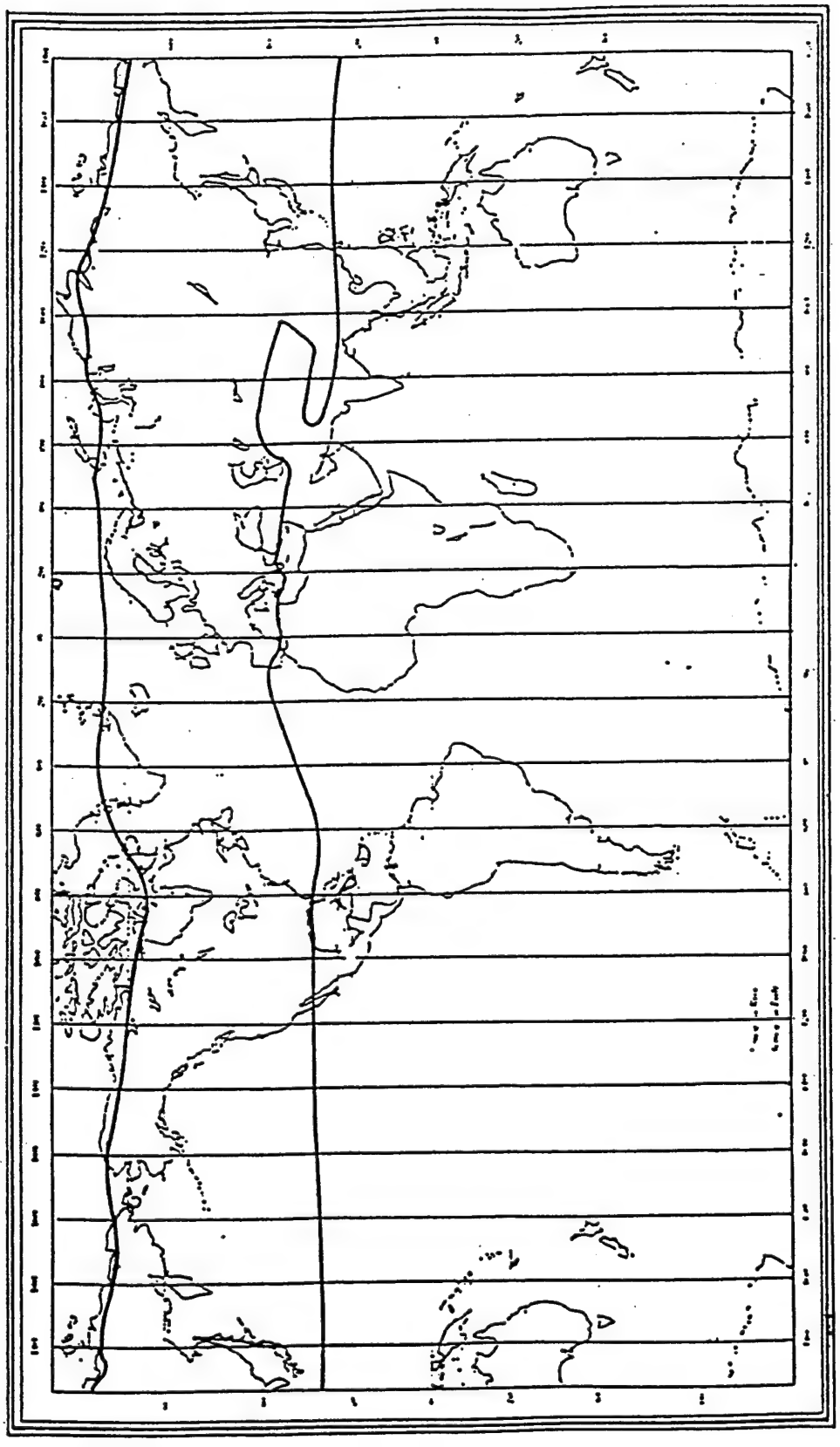


FIGURE A-10. BIRCH (Betula)

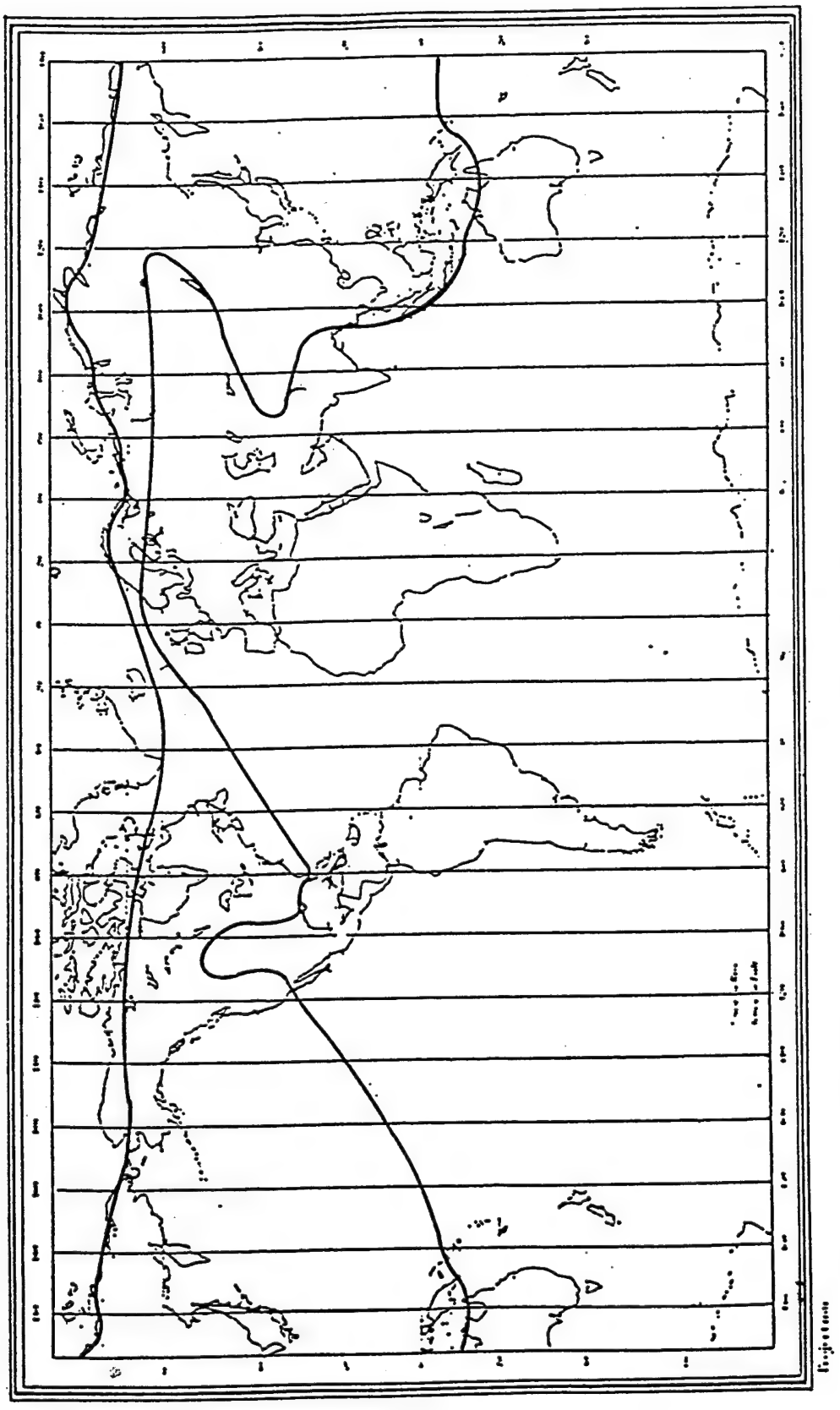


FIGURE A-11. RHODODENDRON, AZALIA (Rhododendron)

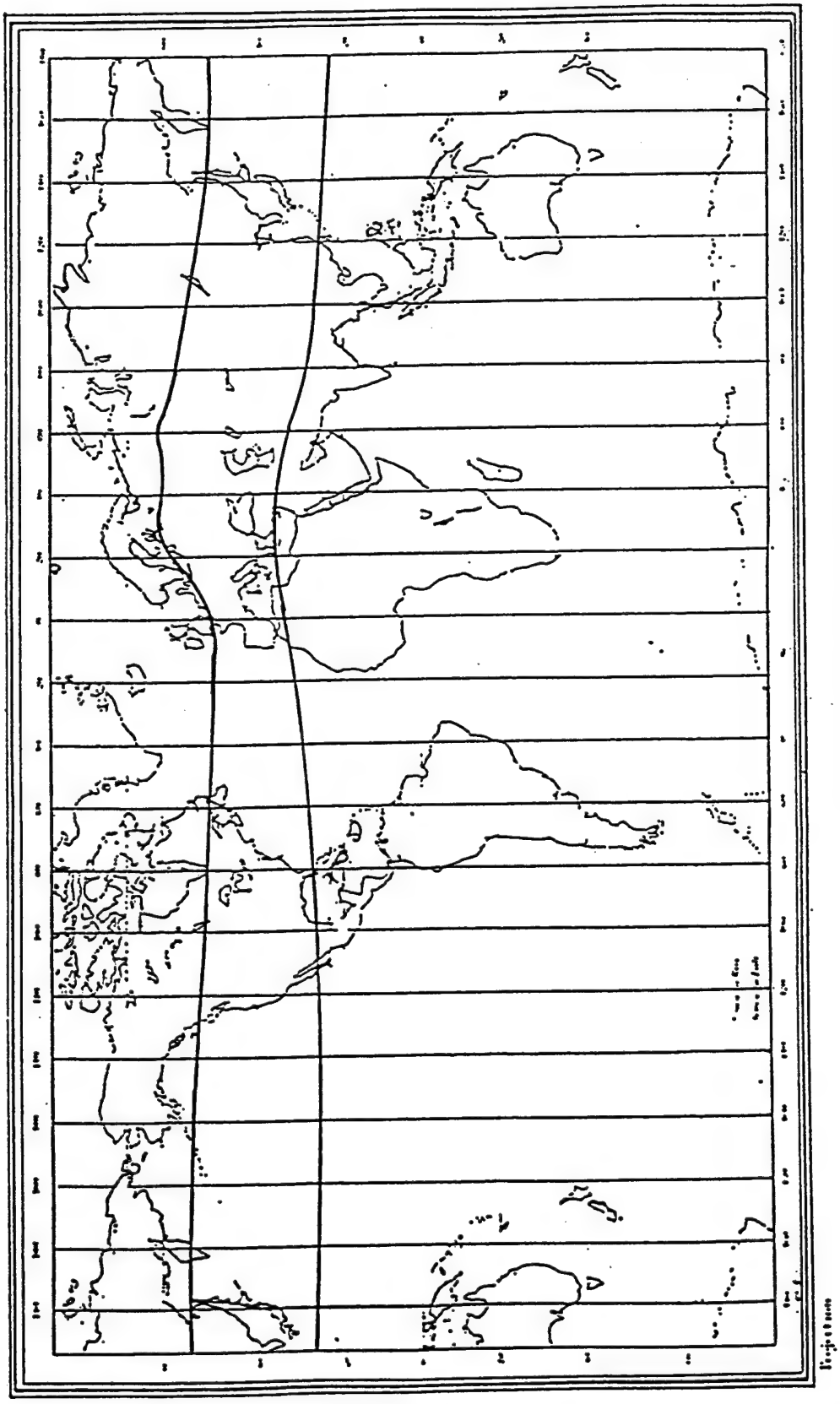


FIGURE A-12. PLUM, APRICOT, ALMOND, PEACH, CHERRY (Prunus)

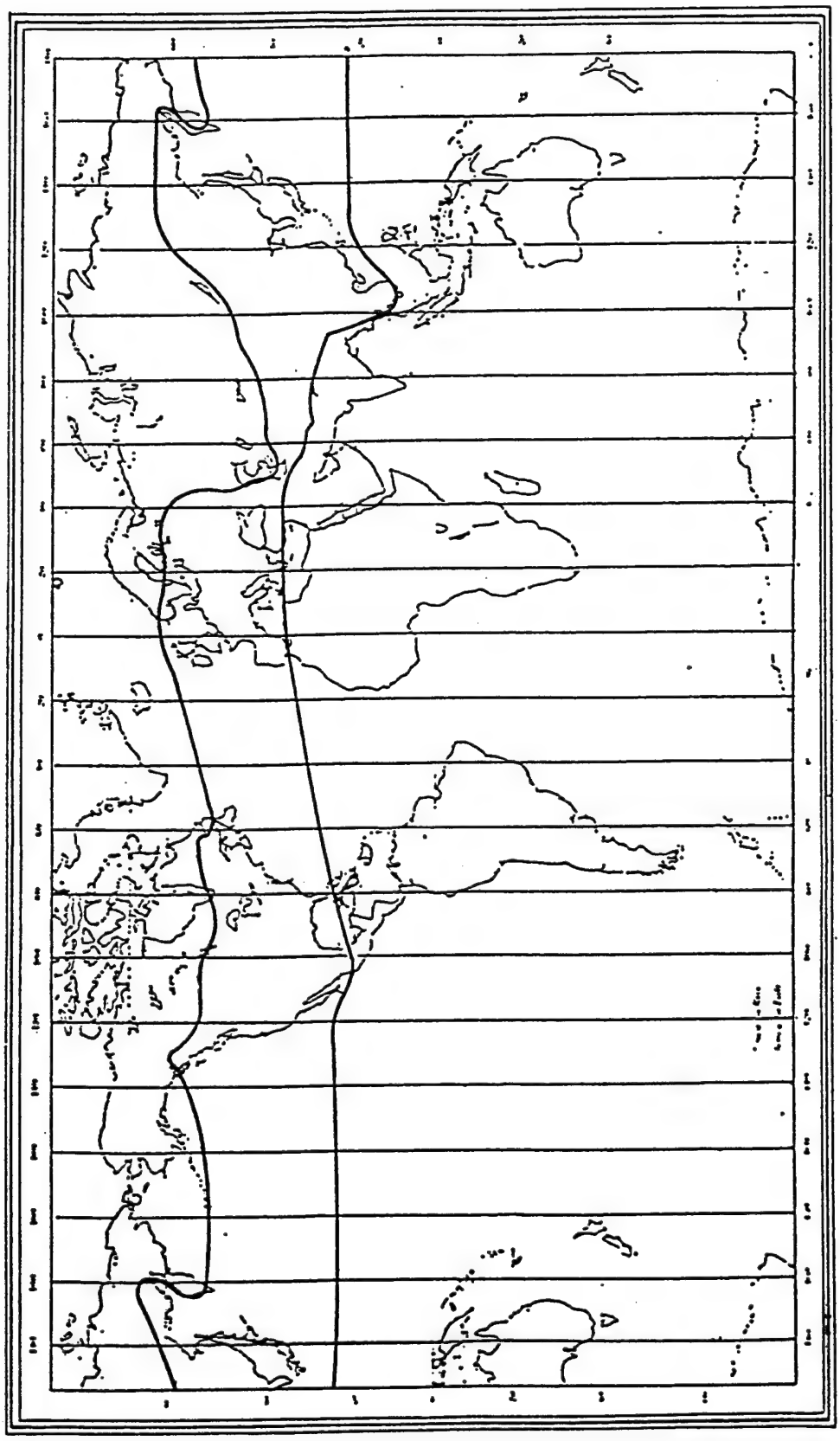


FIGURE A-13. MAPLE (Acer)

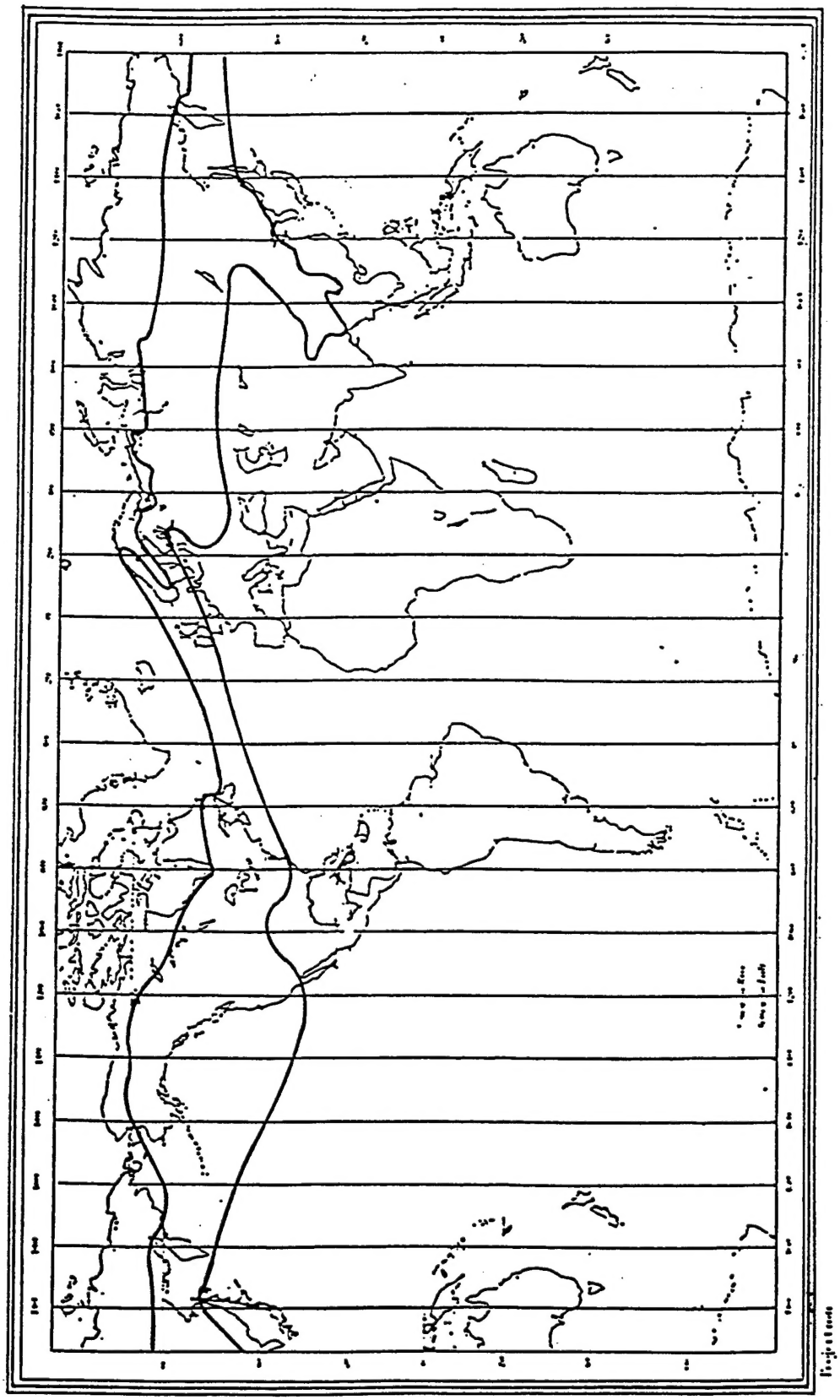


FIGURE A-14. SPRUCE (Pica)

5.0 APPENDIX B

BIBLIOGRAPHY

BIBLIOGRAPHY

Collingwood, G.H. and Brush, Warren. "Knowing Your Trees", 1964. Black and white illustrations of leaves, flowers, fruit and bark of trees.

Dana, James D.; "Dana's Manual of Mineralogy", 1966. Mineral colors.

Edlin, Herbert Leeson. "The Illustrated Encyclopedia of Trees, Timber and Forests of the World", 1978. Lots of pictures showing the overall trees, leaves, and bark in color.

Fairbridge, Rhodes (ed). "The Encyclopedia of Geochemistry and Environmental Sciences", 1972. Good description of earth's crust.

Folk, R.L., "Encyclopedia on Rock Color", 1969. Toward Greater Precision in Rock-Color Terminology. By the Geological Society of America.

Goddard, E.N. "Rock Color Chart", 1951. By the Geological Society of America, National Research Council.

Hara, Bayard. "Oxford Encyclopedia of Trees of the World", 1981.

Johnson, Hugh. "The International Book of Trees", 1980.

Johnson, Hugh. "Hugh Johnson's Encyclopedia of Trees", 1984.

Lambert, David. "The Field Guide to Geology", 1988. Analysis of rock formation and structure.

Line, Les. "The Audubon Society of Trees", 1981.

Lye, Keith. "Minerals and Rocks", 1979. Illustrated source book for the identification of minerals and rocks in color.

Menninger, Edwin. "Flowering Trees of the World", 1962.

National Geographic Society. "Atlas of the World", 1981. Covers worldwide vegetation, rocks, soils, population, etc.

National Geographic Society. "National Geographic Magazines".

Pellant, Chris with Phillips, Roger. "Rocks, Minerals and Fossils of the World", 1990. Good pictures.

Press, Frank. "Earth - Fourth Edition", 1986. Good coverage of the earth's geography.

Sanders, John E. "Principles of Physical Geology"? 1981. Good description of rocks of the world. Some black and white pictures.

Simson, G. and Beck, W. "Life", 1965. Shows vegetation categories and locations.

BIBLIOGRAPHY

Strahler, Arthus N. and Strahler, Alan H. "Modern Physical Geography" 1987. Soil classification and world geographic mapping.

Symonds, George W.D. "The Tree Identification Book", 1958. Black and white illustrations of leaves, twigs and bark of trees.

Tarbuck, Edward J. "Earth Science - Fourth Edition", 1985.

Times Books, "The Times Atlas of the World - Eighth Comprehensive Edition", 1990. Covers worldwide vegetation, rocks, soils, population, etc.

Winkler, Erhard M. "Stone, Properties, Durability in Man's Environment", 1973. Measurement of rock colors.

Zin, Herbert Spencer. "Rocks and Minerals", 1957. Good classification of rocks according to mineral content.